Fundamentals of Analog VLSI Design
Exercise 8 - Problem

Design of the Simple OTA

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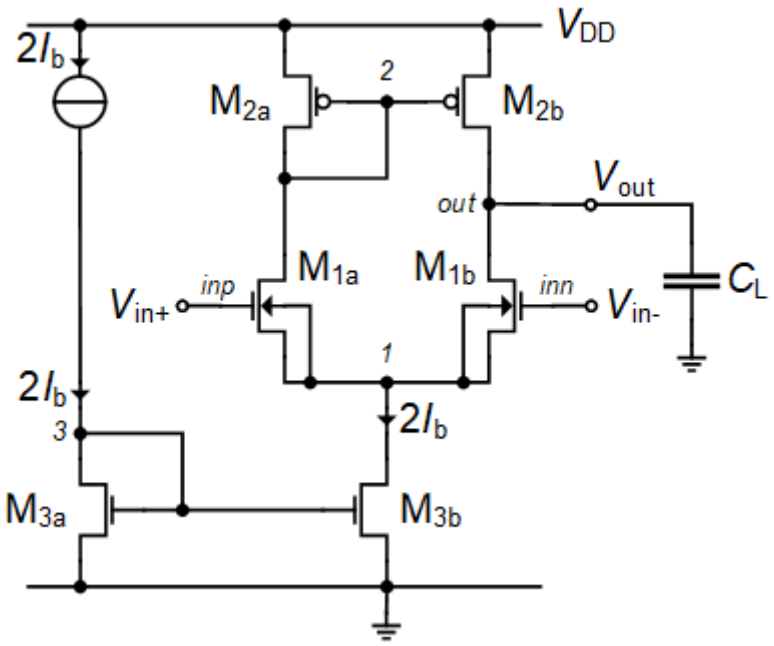

Figure 1: Schematic of the simple differential OTA.

In this exercise we want to design the simple OTA of Figure 1 for the specifications given in Table 1 for a 180nm generic bulk CMOS process. The physical parameters are given in Table 2, the global process parameters in Table 3 and finally the MOSFET parameters in Table 4.

Reuse the analysis given in the lecture notes and use the equations for the design. The difference with the example given in the lecture notes, is the value of the gain-bandwidth product GBW which is ten times higher than the value in the example. This makes the design a bit more tricky because more sensitive to parasitic capacitances.

Follow the design flow proposed below:

- Start sizing the differential pair M_{1a}-M_{1b} using the GBW and DC gain specifications.
- Size the current mirror M_{2a}-M_{2b} using the DC gain specification and taking particular care that the non-dominant pole $\omega_p = G_{m2}/C_2$ is at least 10 times higher than the GBW.
- Finally, size the current mirror M_{3a}-M_{3b} for minimum common-mode input voltage of V_{ic} = 0.6,V$.
- Check that the specification on the random input-referred offset voltage is met.
- Validate your design using the provided qucs-s schematic.

Table 1: OTA specifications.

Specification	Symbol	Value	Unit
Minimum DC gain	A_{dc}	60	dB
Minimum gain-bandwidth product	GBW	10	MHz
Load capacitance	C_L	0.1	pF
Maximum input-referred offset voltage	$V_{os,max}$	4	mV

Table 2: Physical parameters

Parameter	Value	Unit
T	300	K
U_T	25.875	mV

Table 3: Global process parameters

Parameter	Value	Unit
V_{DD}	1.8	V
C_{ox}	8.443	$\frac{fF}{\mu m^2}$
W_{min}	200	nm
L_{min}	180	nm

Table 4: Transistor process parameters

Parameter	NMOS	PMOS	Unit
sEKV parameters			
n	1.27	1.31	-
$I_{spec\square}$	715	173	nA
V_{T0}	0.455	0.445	V
L_{sat}	26	36	nm
λ	20	20	$\frac{V}{\mu m}$
Overlap capacitances parameters			
C_{GDo}	0.366	0.329	$\frac{fF}{\mu m}$
C_{GSo}	0.366	0.329	$\frac{fF}{\mu m}$
C_{GBo}	0	0	$\frac{fF}{\mu m}$
Junction capacitances parameters			
C_J	1	1.121	$\frac{fF}{\mu m^2}$
C_{JSW}	0.2	0.248	$\frac{fF}{\mu m}$
Flicker noise parameters			
K_F	8.1e-24	6.8e-23	J
AF	1	1	-
ρ	0.05794	0.4828	$\frac{V \cdot m^2}{A \cdot s}$
Matching parameters			
A_{VT}	5	5	$mV \cdot \mu m$
A_β	1	1	$\% \cdot \mu m$
Source and drain sheet resistance parameter			
R_{sh}	600	2386	$\frac{\Omega}{\mu m}$
Width and length parameters			
ΔW	39	54	nm
ΔL	-76	-72	nm